AD-A190 795 ELECTRONIC STRUCTURE ELEMENTARY EXCITATIONS OPTICAL AND 1/1
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J J QUINN DEC 87 ARO-20428 1-PH DAAG29-84-K-0008

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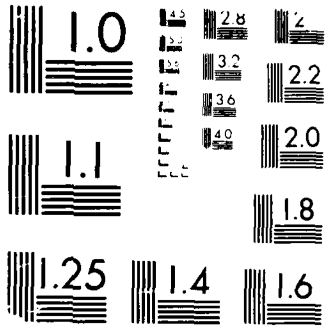

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REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) ARO 20428.1-PH
6a. NAME OF PERFORMING ORGANIZATION Brown Univ. — 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION U. S. Army Research Office
6c. ADDRESS (City, State, and ZIP Code) Providence, Rhode Island 02912	7b. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office — 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DAAG29-84-K-0008
8c. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)
Electronic Structure, Elementary Excitations, Optical and Transport Properties of Semiconductor Superlattices

12. PERSONAL AUTHOR(S)
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13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 8/1/84 TO 10/31/87	December 1987	9

16. SUPPLEMENTARY NOTATION
The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Electronic Structure, Elementary Excitations, Semiconductor Superlattices, Heterostructure, Quantum Well Structures, Quantum Hall Effect

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The following areas have been studied:

(1) Collective Charge Density Excitations in Artificially Structured Materials
  (a) Intra-and Intersubband Excitations of a Semiconductor Superlattice
  (b) Plasmon Bands of Periodic Metallic Heterostructures
  (c) Surface Plasmons in Artificially Structured Solids
  (d) Raman and Inelastic Electron Energy Loss Spectroscopy due to Collective Charge Density Excitations
  (e) Plasmon in Quasi Periodic Layered Electron Gas Systems
(2) Impurity Levels, Excitons, Phonons, and Magnetic Polarons in Quantum Well Structures
(3) The Single Particle Self-Energy in Layered Electron Gas Systems
(4) The Quantum Hall Effect.

The results appear in 58 publications.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code) — 22c. OFFICE SYMBOL

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

ARO 20428.1-PH

FINAL TECHNICAL REPORT

ARO PROPOSAL NUMBER: 20428-PH

PERIOD COVERED BY REPORT: 1 August '84 - 31 October '87

TITLE OF PROPOSAL: Electronic Structure, Elementary Excitations, Optical and Transport Properties of Semiconductor Superlattices

CONTRACT OR GRANT NUMBER: DAAG29-84-K-0008

NAME OF INSTITUTION: Brown University

AUTHORS OF REPORT: John J. Quinn

LIST OF MANUSCRIPTS SUBMITTED OR PUBLISHED UNDER ARO SPONSORSHIP DURING THIS REPORTING PERIOD, INCLUDING JOURNAL REFERENCES:

See Attached List

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Brief Outline of Research Findings:

During the past three years my collaborators and I have studied the following areas:

1) Collective Charge Density Excitations in Artificially Structured Materials

a) Intra-and Intersubband Excitations of a Semiconductor Superlattice

b) Plasmon Bands of Periodic Metallic Heterostructures

c) Surface Plasmons in Artificially Structured Solids

d) Raman and Inelastic Electron Energy Loss Spectroscopy due to Collective Charge Density Excitations

e) Plasmon in Quasi Periodic Layered Electron Gas Systems

2) Impurity Levels, Excitons, Phonons, and Magnetic Polarons in Quantum Well Structures

3) The Single Particle Self-Energy in Layered Electron Gas Systems

4) The Quantum Hall Effect

We give a brief description of each of these topics.

1. Collective Charge Density Excitations

The major portion of our effort has been devoted to understanding the bulk and surface collective charge density excitations in semiconductor superlattices. This work started with the thesis research of my former student, Dr. A. Tselis (Ph.D. -1983), who investigated the self-consistent response of an infinite semiconductor superlattice to an external perturbation of arbitrary space and time dependence. The poles of the response function gave the frequencies of the collective modes as a function of wavevector.

For simple systems in which only the lowest subband of a quantum well was occupied, the modes divide into intrasubband (essentially layered electron gas result) plasmons and intersubband plasmons. The initial work was extended to type II superlattices, superlattices with several occupied subbands, superlattices in which inter-quantum well tunneling occurs, and to magnetic field effects by a number of later collaborators.

Shortly after the Tselis-Quinn work on bulk plasmons in superlattices, Gabriele Giuliani and I investigated the possibility of surface modes of such systems. The novel Giuliani-Quinn surface mode, which is free of Landau damping, was discovered. Later work on bulk and surface modes involved

a) Lateral surfaces (i.e. surfaces which are not perpendicular to the growth direction). Here bands of surface modes are found.

b) Plasmon bands in metallic superlattices

c) Intersubband surface modes

d) The coupling of these modes to external probes via far infrared spectroscopy, Raman scattering, and inelastic energy loss spectroscopy.

The question of plasma modes of a quasi periodic array of two dimensional electron gas layers was studied by Hawrylak and Quinn. For a Fibonacci array, the interesting result that the spectrum is neither localized nor extended, but always in the critical region, was found.

The possibility of amplifying bulk and surface plasmons by application of a drift current was investigated by Hawrylak and Quinn. A patent disclosure was submitted to ARO, but apparently no action was taken.

2. Impurity Levels, Excitons, Phonons and Magnetic Polarons in Quantum Well Structures

The energy of a donor in a GaAs/A $_x$Ga$_{1-x}$As quantum well was studied as a function of

1) the quantum well depth

2) the quantum well width

3) the position of the donor relative to the center of the quantum well

This work was based on a simple variational wavefunction, and gave results that agreed quite well with much more sophisticated calculations. Of particular interest was the energy of the donor for the case in which the donor is located in the barrier. Similar calculations for excitons were studied.

Phonons in superlattices must have a miniband structure due to the superlattice periodicity. The effect of the phonon miniband structure on polariton modes was investigated. Plasmon-polaritons in degenerate polar materials were also studied. To date there has been no complete treatment of spatial dispersion in these studies.

Magnetic polaron effects in semi-magnetic semiconductors like $Mn_xCd_{1-x}Te$ are well known. How the magnetic polaron interaction affects single particle levels and excitons in semimagnetic semiconducting quantum well structures was studied.

3. Single-Particle Self-Energy in Layered Electron Gas Systems

The plasma modes mentioned earlier are a manifestation of the change in dynamic screening associated with layered electron gas (LEG) structures. Once the change in dynamic screening is understood, it is interesting to see how this change affects the single particle self-energies. The effective mass, g-factor, and quasi-particle lifetime are all changed from their values in strictly two dimensional or strictly three dimensional electron gas systems. This work has been taken up in the past year, and preliminary results have already been published.

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